



Transportation Synthesis Report

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Best Practices for Control of Invasive Plant Species

Prepared for
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Transportation Synthesis Reports (TSRs) are brief summaries of currently available information on topics of interest to WisDOT technical staff in highway development, construction and operations. Online and print sources include NCHRP and other TRB programs, AASHTO, the research and practices of other state DOTs, and related academic and industry research.

Request for Report

Invasive plant species are a problem along highway rights of way in Wisconsin and other states. Invasive species introduced from another country, or another region of our own country, tend to displace native plants, lower diversity, change the aesthetics of a habitat and crowd out endangered species. State DOTs are required to avoid the planting of known invasives and must include an analysis of invasive species and future management strategies as part of the National Environmental Policy Act (NEPA) process for new projects.

RD&T was asked to review strategies/approaches/best practices for controlling non-native plants in highway rights of way with a focus on neighboring states' practices. These species are of specific interest: **Canada thistle, leafy spurge, field bindweed, wild parsnip, spotted knapweed and garlic mustard**. Also, are there additional species beyond these six that are a problem in neighboring states; if so, how are they being controlled? Research on biological controls, such as insects, used to combat these species would also be of interest.

Summary

A search of national, regional and state Web sites and databases yielded extensive information on invasive plant species, with the U.S. DOT providing significant leadership. All states have either an invasive plants or noxious weed law; many localities have similar ordinances. In Wisconsin, the Department of Natural Resources, The Nature Conservancy and the University of Wisconsin appear to be at the forefront of inventory and management initiatives related to invasive species. An effort is currently under way to revise Wisconsin's law and approach to invasives.

Successful management strategies emphasize correct identification, inventory and mapping of invasive species; classification of the threat; and integration of management strategies as part of a wider vegetation management plan. Successful control must be coordinated with major landowners, such as Wisconsin DNR, the U.S. Fish and Wildlife Service, the U.S. Forest Service, and counties and utilities involved in highway rights of way.

Below we organize specific information in the following categories:

- Control Strategies for Six Species of Concern
- New Invasive Species in Neighboring States
- Biological Controls
- Wisconsin Efforts and Resources
- Neighboring States' Control Practices
- U.S. DOT Resources and Guidelines
- Other Significant Resources

Control Strategies for Six Species of Concern

The information on control of the six species of concern is compiled from the following sources:

- Wisconsin Department of Natural Resources (WI DNR) Manual of Control Recommendations for Ecologically Invasive Plants
http://www.dnr.state.wi.us/org/land/er/invasive/manual_toc.htm
- The Nature Conservancy (TNC) Invasive Plant Element Stewardship Abstracts (ESA)
<http://tncweeds.ucdavis.edu/esadocs.html>
- Illinois Natural History Survey (INHS)
<http://www.inhs.uiuc.edu/chf/>
- Invasive Species.gov, a Web site maintained by the National Agricultural Library for the National Invasive Species Council (NISC)
<http://www.invasivespecies.gov/>
- Invasive Plants Association of Wisconsin (IPAW)
<http://www.uwex.edu/ces/ipaw/>
- Invaders Link Search, University of Montana
<http://invader.dbs.umt.edu/linksearch/linksearch.asp> A database of approximately 10,000 links to Web sites containing information about any one of 693 species. Here you will be able to search by plant scientific name for links to other Web sites containing photographs, distribution data and other information pertaining to a specified plant.

Canada Thistle (Cirsium arvense)

Illinois Fact Sheet

<http://www.inhs.uiuc.edu/chf/outreach/VMG/cthistle.html>

Late spring burns are the recommended treatment; early spring burns can increase sprouting and reproduction.

WI DNR Fact Sheet

<http://www.dnr.state.wi.us/org/land/er/invasive/factsheets/canada.htm>

Healthy, dense prairie vegetation can produce enough competition to reduce the plant's abundance; encouraging the development of communities with native species is the best prevention for establishment. Spot application of the amine formulation of 2,4-D using a wick applicator or hand sprayer can control individual stems if necessary. Infested lands that are not considered high quality natural areas may be controlled using a foliar application of a 1 to 2 percent active ingredient solution of glyphosate in spring when plants are six to 10 inches tall.

Invaders Link Search (UM)

http://www.css.orst.edu/weeds/Canadian_thistle/control.htm

Biological control; selective and nonselective chemical control.

<http://www.fs.fed.us/database/feis/plants/forb/cirarv/all.html#> (scroll to "Other Management Considerations")

To date, biological control of Canada thistle has not been successful, although some biological control agents (for example, *Ceutorhynchus litura* and *Cassida rubiginosa*) suppress it to a limited extent and may be effective when combined with other control methods.

Leafy Spurge (Euphorbia Eusula)

WI DNR Fact Sheet

<http://www.dnr.state.wi.us/org/land/er/invasive/factsheets/spurge.htm>

Fire, cultivation, obscuring sunlight and mowing have not been successful. The USDA has experimentally released five beetles and one midge: tests in Montana showed up to a 90 percent reduction in spurge population. Experimental releases in a few Wisconsin sites since 1995 have shown good insect reproduction, and impact on spurge is becoming evident. Until a proven biological control is approved, herbicides appear to be a temporary solution. Picloram is the most effective chemical control, but should not be used on high quality natural areas. It may seriously affect woody species. A 90 percent reduction of leafy spurge was achieved at the University of Wisconsin Arboretum, where a 3 percent active ingredient solution of fosamine was applied to blooming plants in June and July.

TNC ESA

<http://tncweeds.ucdavis.edu/esadocs/documnts/euphesu.html>

Some of the more promising agents for biocontrol of spurge are: stem and root borers, such as the cerambycid *Oberea erythrocephala*, and the clear-winged moth *Chamaesphecia tenthrediniformis*; the gall midge *Bayeria*

capitigena, which prevents flowering of spurge; and the rust fungus *Uromyces scutellatus*, which devastates shoots by causing systemic infections.

North Dakota's Leafy Spurge News

<http://www.team.ars.usda.gov/lnews.html>

May 2002 (Letter to Editor): The current success with biological control may cause some to depend too heavily on it. It will take biological control agents many years to catch up. To help the "bugs" catch up, we need to continue using herbicides, sheep or goat grazing and all the other less glamorous leafy spurge management tools to prevent further spread and infestation. (Link to Team Leafy Spurge Web site featuring products and Web-accessible items: <http://www.team.ars.usda.gov>)

Invaders Link Search (UM)

<http://www.for.gov.bc.ca/hfp/noxious/leafy.htm#>

Beetles and moths as biological control agents.

<http://entweb.clemson.edu/caps/ppq.htm>

Scroll down for a list of insect species and fungus being used or considered for use by the USDA Animal and Plant Health Inspection Service (APHIS) as biocontrol agents.

Field Bindweed (Convolvulus arvensis)

TNC Fact Sheet

<http://tncweeds.ucdavis.edu/esadocs/convarve.html>

In a 1995 survey, managers for The Nature Conservancy preserves ranked the likelihood of field bindweed control "medium" to "low." Field bindweed control entails chemical applications, disking or hand-pulling on a regular basis (perhaps only once per year), plus yearly monitoring. The herbicide 2,4-D is generally the most effective against field bindweed, but glyphosate can provide some control. Mowing is unsuccessful because plants can be missed and it encourages ground-hugging growth. Burning alone is not an effective control method.

Invaders Link Search (UM)

<http://www.mtwow.org/field-bindweed-ID.html>

Biological control: The insect *Aceria malherbae nuzzaci* helps control field bindweed by attacking the leaves, making them fold inward along the mid-vein and develop a fuzzy texture. Heavily infested shoots became stunted and distorted from this insect. The insect *Tyta luctuosa* (a dark brown moth) larvae will defoliate field bindweed. Also, goats and sheep will eat the plant.

Wild Parsnip (Pastinaca sativa)

Illinois Fact Sheet

<http://www.inhs.uiuc.edu/chf/outreach/VMG/parsnip.html>

The best control is achieved mainly through hand-pulling. Mowing probably favors parsnip maturation by allowing more sunlight to reach immature parsnip plants. Mowing also reduces the density, height and flowering of other species that are potentially good competitors, such as common goldenrod.

WI DNR Fact Sheet

<http://www.dnr.state.wi.us/org/land/er/invasive/factsheets/parsnip.htm>

A very effective control method is to cut the entire root just below ground level with a sharp shovel or spade. If the population is too large to hand-cut or pull, a power brush-cutter can be used just after peak flowering and before the seeds set. Chemical controls are effective, but should be used sparingly on quality natural areas. The best method is to burn the site, then follow with spot application of 1 to 3 percent active ingredient glyphosate.

Invaders Link Search (UM)

<http://www.funet.fi/pub/sci/bio/life/plants/magnoliophyta/magnoliophytina/magnoliopsida/apiaceae/pastinaca/index.html>

Links to information about insects that use wild parsnip as a food plant.

Spotted Knapweed (Centaurea maculosa)

WI DNR Fact Sheet

<http://www.dnr.state.wi.us/org/land/er/invasive/factsheets/knapweed.htm>

Chemical controls are an effective means of eliminating spotted knapweed, but toxicity can be a concern. Picloram and clopyralid are the most commonly used and effective herbicides. Biological controls include two

root mining moths, a flower moth and a root mining beetle. Most promising are the two seed-head attacking flies *Urophora affinis* and *U. quadrifasciata*. Mowing has not been successful. Once established, knapweed may be reduced by hot prescribed burns. This can be followed by selective pulling and digging once the population has been decreased.

Invaders Link Search (UM)

<http://www.for.gov.bc.ca/hfp/pubs/interest/bioagent/spotted.htm>

Biological control agent matrix.

<http://www.nysaes.cornell.edu/ent/biocontrol/weedfeeders/wdfdrtoc.html>

Scroll down to "Diffuse Knapweed and Spotted Knapweed Control Agents" for a list of 13 biological control agents.

<http://www.idealibrary.com/links/doi/10.1006/bcon.1999.0787>

Abstract on the use of *Agapeta zoegana* L. for biocontrol of spotted knapweed.

Garlic Mustard (Alliaria petiolara)

WI DNR Fact Sheet

<http://www.dnr.state.wi.us/org/land/er/invasive/factsheets/garlic.htm>

Minor infestations can be eradicated by hand pulling at or before the onset of flowering, or by cutting the flower stalk as close to the soil surface as possible just as flowering begins. Dense populations may be controlled by fall burning, when leaf litter provides adequate fuel. Three to five years of burning are required, to be followed by hand-pulling or cutting small populations produced from the seed bank.

UW-Madison's Weed Science article

http://ipcm.wisc.edu/uw_weeds/extension/articles/garlicmustard.htm

Scientists at Cornell University plan to do research on biological control of garlic mustard but at this time there are no known biological control agents to suppress this weed.

US NISC Page

<http://www.invasivespecies.gov/profiles/garlmust.shtml>

Basagran (bentazon) was found to be highly effective when applied in midsummer to control first-year rosettes growing in dense stands.

New Invasive Species in Neighboring States

Illinois

(From Debra Nelson, Illinois DNR, dnelson@dnrmail.state.il.us [815-675-2386x321])

One that is new to me and new to northeastern Illinois that I know of is Oriental Bittersweet. It may not be a real problem along roadsides as it's primarily a woodland plant, but it took over an acre (in a Kudzu-like fashion) at Illinois Beach State Park in one year. Also, Cypress spurge has been a big problem at Illinois Beach in sandy areas even though it is not generally considered a big problem in black soil prairies. It will invade open and partially shaded sites and seems to be impossible to eradicate.

Leafy spurge is making disturbing headway in Lake and McHenry counties and I am afraid it is being spread by roadside mowing at this very moment. I am in the process of trying to contact local highway commissioners and IDOT to try to prevent the widespread dispersal of seed via mowers. The timing of seed production coincides with the usual first roadside mowing around here.

Plants that are likely to be terrestrially invasive in Wisconsin

(R) = frequently spread by roadsides

(From Kelly Kearns, WI DNR, kearns@dnr.state.wi.us [608-267-5066])

Absinth wormwood, amur maple, alsike clover (R), baby's breath, bladder campion (R), bristly locust, burnett saxifrage (R), Chinese silver grass (R), cork tree, crack willow, creeping bent-grass (R), creeping buttercup, English ivy, eulalia, everlasting pea (R), feathertop, garden heliotrope (R), goutweed, hairy willow-herb (R), hawkweed (R), Japanese hedge-parsley (R), Japanese stilt grass, lesser celandine, marsh thistle, mile-a-minute vine, ox-eye daisy (R), pale swallow-wort, porcelain berry, princess tree, queen-of-the-prairie (R), redtop, sawtooth oak, Siberian peashrub, stinging nettle, tall buttercup, tall mannagrass (R), tansy ragwort (R), white campion (R), white willow, wineberry, winged euonymus, winter creeper, woodland angelica.

Plants that are likely to become a serious problem in some Wisconsin areas, or are currently a serious problem in similar states

(R) = frequently spread by roadsides

(From Kelly Kearns, WI DNR, kearns@dnr.state.wi.us [608-267-5066])

Big-leaf lupine (R), black swallow-wort, cheat grass, Chinese lespedeza (R), Chinese yam, colt's foot (R), field hedge-parsley (R), giant hogweed (R), giant knotweed (R), Japanese honeysuckle, Kudzu, musk thistle (R), plumeless thistle (R), poison hemlock (R), Russian knapweed (R), tree of Heaven, tumble knapweed (R), wild chervil (R), yellow starthistle (R).

On the Web

<http://www.dnr.state.wi.us/org/land/er/invasive/manuallist.htm>

(Scroll to "Potential Problem Species...")

Lists exotic and native species that are potentially threatening to Wisconsin's native habitats. Many are already invasive in the state on a local scale, and others (marked with a #) have become serious problems in other parts of the Midwest and may become troublesome in Wisconsin in the future.

<http://216.239.41.100/search?q=cache:cAfRT5jXRJwJ:www.botany.wisc.edu/wisflora/Composition.html+glossy+buckthorn+--+with+significant+consequences&hl=en&ie=UTF-8>

Scroll to "Ecologically Invasive Plants."

Species that are more recently arrived in Wisconsin and are just beginning to become problematic in natural areas include *Rhamnus frangula* L. -- glossy buckthorn -- with significant consequences for the native vegetation.

<http://www.dnr.state.wi.us/org/land/er/invasive/info/loose2.htm>

Purple loosestrife is a serious threat to Wisconsin wetlands. The plant also flourishes in roadside ditches. Its numbers and rate-of-spread have increased rapidly in the Midwest during the past 15 to 20 years. Purple loosestrife can be found throughout Wisconsin, but it is still in low density in most areas.

<http://www.seagrant.umn.edu/seiche/dec.02/art09.html>

Minnesota Sea Grant recently completed a print run of 1.1 million aquatic nuisance species "watch" identification cards that are being distributed in the U.S. and Canada.

Biological Controls

The following resources are focused on biological control strategies for invasive species.

UW Department of Entomology *Biological Control News*

<http://www.entomology.wisc.edu/mbcn/mbcn.html>

Contains a searchable index which includes species of interest, however, information may be dated. The site provides links to other biological control sites worldwide. A free "irregular" e-newsletter is also available at this site. Articles of particular value to this report include:

- From Volume 7, No. 3 (October 2000): *Current Insect Biocontrol Projects in the Midwest*, <http://www.entomology.wisc.edu/mbcn/mbcn703.html>
- From Volume 7, No. 2 (August 2000): leafy spurge, the flea beetle and fire, <http://www.entomology.wisc.edu/mbcn/mbcn702.html>
- From Volume 7, No. 1 (May 2002): *Canada Thistle Biocontrol Agent Can be Collected in Alfalfa*, <http://www.entomology.wisc.edu/mbcn/mbcn701.html>

Mn/DOT Roadside Management and Pesticide Information

<http://www.dot.state.mn.us/environment/programs/MPRC.html>

Has contact information and details on insect biocontrol used on leafy spurge and spotted knapweed. Most districts and some counties have reportedly developed Integrated Roadside Management Programs. The programs serve as a proactive way to address roadside management and to respond to the Groundwater Act of 1989 (Chapter 326, Article 5, Section 18B.063) and the 1994 amendment to the Act (Chapter 558, Section 26). Mn/DOT cooperates with the Minnesota Department of Agriculture and APHIS in releasing biological control agents.

FHWA E-newsletter *Green Roadsides, Fall 2001*

<http://www.fhwa.dot.gov/environment/greenerroadsides/fal01p9.htm>

Michigan:

In 1994, the Michigan DNR received approval to release beetles on several invasive-infested state game areas with the help of trained local groups around the state to rear the beetles, release them and monitor their effect. A reduction in density by 80 percent is expected in 10 to 20 years (Conservation Notes, 1998).

MSU Center for Integrated Plant Systems Biological Control Program

<http://www.cips.msu.edu/biocontrol/index.htm>

Many specific beneficial beetle species are profiled; some are known to be consumers of invasive weeds. Note that many management techniques, such as tillage, mowing and herbicide use may negatively effect these insects; preservation of undisturbed filter strips is often emphasized for farmers looking for guidance in weed management.

Cornell University Biological Control Gateway

<http://www.nysaes.cornell.edu/ent/biocontrol/>

Contains links to biological control research on a variety of species, including weeds. The following link contains evaluations of biocontrols on leafy spurge and spotted knapweed. Some of the biocontrols discussed have been released and tested in Wisconsin.

<http://www.nysaes.cornell.edu/ent/biocontrol/weedfeeders/wdfdrtoc.html>

Biological Control of Leafy Spurge

This multimedia CD-ROM contains resources focusing on biological control of the weed, including a narrated PowerPoint presentation and an extensive photo section. Further information is available through the TEAM Leafy Spurge Web site at <http://www.team.ars.usda.gov>, or by e-mail at teamls@sidney.ars.usda.gov

Association of Natural Biocontrol Producers (ANBP)

<http://www.anbp.org/>

ANBP is a professional association representing the biological pest management industry. There are links to member products, ANBP's newsletter, biocontrol researchers and publication lists, and further links to non-commercial sites featuring IPM, pests, images and biocontrol.

Iowa State Entomology Index: Biological Control

http://www.ent.iastate.edu/List/biological_control.html

Links to numerous U.S. and international biocontrol sites covering a variety of topics.

Minnesota Department of Agriculture Weed Biocontrol Project

<http://www.mda.state.mn.us/weedcontrol/>

This database has been developed to manage the large volume of data generated by each individual weed biocontrol project in the state and to provide federal, state and county agencies a means for assessing the status of natural enemy releases and the effects they are having on their target weeds throughout Minnesota.

Biological Control Agents of Invasive and Exotic Species of North America

<http://www.invasive.org/biocontrol.cfm>

Links to descriptions and photos of more than 150 agents.

Inundative Control Using Mycoherbicides

<http://www.landcareresearch.co.nz/research/biosecurity/weeds/biocontrol/inundativemycoherbicides.asp>

Plant pathogens can be used to control weeds in a way similar to chemical herbicides.

Wisconsin Efforts and Resources

http://www.uwex.edu/ces/ipaw/newsletter/weed_laws.htm

Wisconsin has long recognized the need to completely overhaul its state weed laws. In 1998 a Weed Law Technical Advisory Committee was established. Composed of representatives from affected industries and concerned organizations, the committee reviewed regulations in effect in other states and studied the needs in our state. A proposal for a new Wisconsin weed law was drafted by the committee and then sent to the public for review and input. An attempt to make the proposal part of the state Department of Natural Resources 2001-2003 budget resulted in only the aquatic weed portion being retained. Those who worked to draft the proposal are hoping the rest of the proposal will be introduced into the legislature as a separate bill.

The proposal sets up four statewide, and two local, categories of weeds with varying levels of restrictions. Anyone could submit a petition for a species to be designated in one of those categories. An appointed Noxious Weed Council would make recommendations for placing specific plants in each of these categories based on scientific findings. This proposal is based on limited enforcement, assistance by state and local agencies, voluntary cooperation by landowners and extensive training and public education. It also requests minimum staffing (three) and funding to be divided into three agencies. Additional funds would be needed for financial and technical assistance to landowners.

Link to the draft recommendations for weed law program revisions:

<http://www.dnr.state.wi.us/org/land/er/news/wlctl.htm>

UW-Madison Extension Agronomy/Weed Science

http://ipcm.wisc.edu/uw_weeds/extension/agronad.htm

Invasive Plant Association of Wisconsin (IPAW)

<http://www.uwex.edu/ces/ipaw/index.htm>

State coalition of local, state, private and nonprofit organizations. IPAW produces a newsletter, fosters local partnerships, conducts an annual conference (scheduled for Sept. 27, 2003 in Madison) and is currently conducting an invasive plant survey in partnership with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC). This survey looks like it will be of use to DOT managers, as it utilizes a widely accepted classification schema, and will also be evaluating species of potential threat in the future.

(Link to survey information: <http://www.uwex.edu/ces/ipaw/newsletter/survey.htm>)

GLIFWC Exotic Plant Info Center

<http://www.glifwc.org/epicenter/>

Contains information on the survey (but information is dated), educational and mapping links. However, GLIFWC publishes annual reports on invasives of interest to the 11 Ojibwa tribal members located in Minnesota, Michigan and Wisconsin.

UW-Extension/Sauk County Invasives Control Network

<http://www.uwex.edu/ces/ipaw/newsletter/sauk.htm>

Partnership effort to train county and town patrolmen/highway department personnel, pair each with a conservationist and assign right of way segments for control. Partners and contact information listed here.

Wisconsin State Herbarium

<http://www.botany.wisc.edu/herbarium/>

Provides a tremendous resource of information on native plants, including the Wisconsin Biomapper, which provides GIS mapping capabilities at the following site: <http://maps.botany.wisc.edu/website/herbarium/viewer.htm>

Neighboring States' Control Practices

- **Minnesota** DNR invasive/harmful exotic species Web site: <http://www.dnr.state.mn.us/exotics/index.html>
Currently there are about 2,000 purple loosestrife infestations recorded in 68 of Minnesota's 87 counties. Of those sites, the majority (70 percent) are lakes, rivers or wetlands. Inventory totals indicate that the state presently has more than 58,000 acres infested with purple loosestrife. The DNR's management program integrates chemical and biological control approaches and cooperates closely with local, state and federal groups involved in purple loosestrife management.
- **Iowa** DNR REAP Roadside Vegetation Management Program: <http://www.iowadnr.com/reap/roadside.html>
- **Missouri** Department of Conservation Exotic Species: <http://www.conservation.state.mo.us/nathis/exotic/> The Missouri Department of Conservation has identified a number of exotic plants that are capable of aggressively spreading into its native ecosystems, including: purple loosestrife, common buckthorn, shrub or bush honeysuckles, and sweet clover. Descriptions and control methods for these species and others are available on the department's Web site at www.conservation.state.mo.us/nathis/exotic (click "Vegetation Management Manual").
- **Illinois** Vegetation Management Guide (Illinois Nature Preserves Commission): <http://www.inhs.uiuc.edu/chf/outreach/VMG/VMG.html> Contains fact sheets with management guidelines on their species of concern, including several identified as species of concern:
 - Canada thistle: On large sites (old fields, ditch banks, roadsides) with heavy infestations, thistles should be mowed as close to the ground as possible when in full bloom. Cut flower heads should be removed. Mowing may be needed over several years to obtain adequate control.
 - Garlic mustard: Spot application of 2 percent Roundup to the foliage of individual plants is effective during spring and fall when most native vegetation is dormant but garlic mustard remains green. Herbicide should be applied when air temperature is above freezing.
 - Wild parsnip: If mechanical methods have failed to control wild parsnip or are not feasible, a 2 percent spot application of Roundup to basal rosettes is a recommended treatment. Roundup should be applied to individual plants with a hand sprayer in late fall.

- **Indiana DNR invasive plant species Web site:**
<http://www.in.gov/dnr/naturepr/species.html> Some of the more well-known non-native invasive plants include purple loosestrife, Japanese honeysuckle, autumn olive, buckthorn and garlic mustard. The Division of Nature Preserves along with nonprofit organizations, other environmental organizations and land trusts focus a great deal of resources on controlling undesirable non-native and invasive species in natural areas.
- **Michigan Invasive Plants Council:**
<http://forestry.msu.edu/mipc/Default.htm> Contains links to weed lists and other general reference sites, including Wisconsin's.
- **MSU Extension Invasive Weeds of the Upper Peninsula:**
<http://forestry.msu.edu/mipc/UPweeds.htm> Includes classification system; spotted knapweed, leafy spurge and garlic mustard are classified as "highly invasive." Canada thistle is listed as category 2, or less invasive.

U.S. DOT and National Resources and Guidelines

Roadside Vegetation Management

<http://www.fhwa.dot.gov/environment/vegmgt/index.htm>

This gateway site links to the FHWA approach, which is to develop integrated and comprehensive vegetation management plans to address multiple objectives, including prevention and eradication of invasive plant species. The site contains links to policy guidance, resources, a newsletter, and a handbook (of which two parts are online -- the link to order the full volume is online).

Links to:

- The Invasive Species Web page: <http://www.fhwa.dot.gov/environment/vegmgt/invasive.htm>
This page provides further links to The National Invasive Species Management Plan, Executive Order 13112 on Invasive Species, the Federal Interagency Committee for the Management of Noxious and Exotic Weeds, and a PowerPoint presentation on combating invasive plants.
- The National Invasive Species Management Plan: <http://www.invasivespecies.gov/council/nmp.shtml>
The plan is a good overview of all federal agencies involved in invasive species control, and details each agency's role and relative legal responsibilities.

Greener Roadsides, a free quarterly e-mail newsletter

<http://www.fhwa.dot.gov/environment/greenerroadsides/fall01.htm>

The first article contains suggested maintenance and construction BMPs. The ninth article details projects and approaches initiated by state DOTs in eight states. Most successful projects build on interagency and/or local partnerships in identification and management strategies.

National Invasive Species Council

<http://www.invasivespecies.gov/council/nmp.shtml>

Established by executive order, the council includes secretaries and administrators of 11 federal agencies, including the U.S. DOT. This gateway site includes species information and provides a good overview of state efforts. (This page lists a wide variety of newsletters available, including biocontrol information:

<http://www.invasivespecies.gov/other/newsletters.shtml>)

The Nature Conservancy - Wildland Invasive Species Team

<http://tncweeds.ucdavis.edu/index.html>

TNC is probably the U.S. leader in real-world experience in comprehensive assessment, eradication and management of invasives on its properties (including the many holdings in Wisconsin). The site maintains an excellent listserv (participants include Wisconsin DNR staff); archives include discussions of species of concern, among them:

- Wild parsnip -- ... The steady decline in parsnip density in the unmowed plot suggested that in situations where other plants are able to offer competition, the best parsnip control measure is to do nothing. Burning removes litter and taller plants allowing parsnip rosettes to develop rapidly. When present, wild parsnip rosettes are among the first plants to green up after an early spring burn and become easy to detect and dig up with a shovel. The parsnip webworm damages some individual plants severely, but is not known to devastate whole patches and is not likely to be useful as a biocontrol agent.
- Spotted knapweed -- can be controlled with picloram (4-amino-3,5,6-trichloropicolinic acid) and 2,4-D but there are problems. Control by 2,4-D is temporary since it does not prevent germination from seeds in the soil. Picloram persists in soils but in four years enough is lost from a .4-.6 kg/ha treatment to allow germination and

reinfestation. Burning might be considered in areas with enough surrounding vegetation or litter to carry a controlled burn. Mowing would probably be a way to control populations but not eradicate them.

The site also includes Species Management Abstracts (ESAs by Latin name), tool reviews and an early warning system. The “Weed Control Methods Handbook” is available at the following address:

<http://tncweeds.ucdavis.edu/handbook.html>

The biocontrol section contains an excellent overview, including some discussion of species of concern-

<http://tncweeds.ucdavis.edu/products/handbook/06.BiologicalControl.doc>:

- Leafy spurge (Section 4.4): Lym and Nelson’s recent (2000) paper on impacts of two flea beetle species released against leafy spurge is the only published study that quantifies population level impacts of any of the 13 insect biocontrol species released against this plant in the U.S. and Canada. They found that both flea beetles, *Aphthona lacertosa* and *A. czwallinae*, reduced leafy spurge stem densities by about 65 percent up to 16m from initial release sites within three to five years. A mixed population of both species reduced stem densities by more than 95 percent within four years after release. (Section 4.14- The Team Leafy Spurge homepage (<http://www.team.ars.usda.gov/>) has excellent information on biocontrol, including a downloadable 24-page booklet entitled *Biological control of leafy spurge* with advice on obtaining and releasing insects.)
- Spotted knapweed (Section 4.5): Programs to control this plant have not yet been successful despite years of effort and releases of several insect species against it. Recent research indicates that biological control agents may also have undesirable indirect impacts on nontarget plants and animals. Callaway et al (1999) found that when knapweed root moth fed on the roots of spotted knapweed neighboring Idaho fescue plants did more poorly than when grown with unattacked knapweed. A study in Montana found that two spotted knapweed biocontrol agents, the gall flies *Urophora affinis* and *U. quadrifasciata*, were the primary food item for deer mice for most of the year and made up 84 to 86 percent of their winter diet.
- Canada thistle (Section 4.4): Programs to control this plant have not yet been successful despite years of effort and releases of several insect species against it.
- Field bindweed (Section 4.8): At least one biocontrol agent has been released in the U.S. against this plant.
- Garlic mustard (Section 4.9): Currently the subject of research and testing as a possible target for future biocontrol releases.
- (Section 4.10): Excellent updates on natural area weed biocontrol projects are available at <http://www.cabi.org/BIOSCIENCE/weeds.htm> and at <http://www.nysaes.cornell.edu/ent/biocontrol/weedfeeders/wdfdrtoc.html>
- (Section 4.14): There are also several Web sites with good information about specific weed biocontrol agents and how to obtain them- <http://www.for.gov.bc.ca/hfp/pubs/interest/bioagent/bioagent.htm> <http://www.nysaes.cornell.edu/ent/biocontrol/weedfeeders/wdfdrtoc.html>
- (Section 4.14): Some weed biocontrol agents are also available from commercial suppliers. You can download a publication with a list of 143 suppliers of 130 organisms used for biocontrol of weeds, insects and other pests from the California EPA Department of Pesticide Regulation Web site at: <http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm>

From Section 4.17 -- Compounds derived from several pathogenic organisms have shown promise for use as bioherbicides against wildland pests but development of delivery systems for some has proven difficult. Gary Strobel of Montana State University isolated a compound toxic to spotted knapweed from cultures of *Alternaria alternata*, a fungal pathogen specific to it. The compound, named maculosin, may be produced synthetically and may find use as a species-specific herbicide against spotted knapweed.

Montana State University - Center for Invasive Plant Management (CIPM)

<http://www.weedcenter.org/>

Although centered on western lands, CIPM also offers access to management resources of interest.

North American Weed Management Association

http://www.nawma.org/title_page.html A coalition of mainly western states and federal agencies, this site also contains access to mapping standards, which are designed to be suggested minimums, yet also be compatible with existing survey and inventory instruments.